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ENGINEERING PRODUCT SPECIFICATION, PART 1
REMOTE LINE PRINTER, RLP 300

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1.0 GENERAL DESCRIPTION

This Engineering Product Specification, Part 1, has been prepared to define the remote line printer subsystem (RLP 300) to satisfy the WWMCCS requirements. The subsystem shall provide multiple hard-copy printouts at remote stations. The printer shall be capable of printing 132 columns at a speed of 300 lines per minute on 6 part continuous business forms, and producing at least 6 lines per inch.

The subsystem will utilize the HONEYWELL MBP 12 line printer. A communication interface and control module will be designed and added to the MBP 12 printer in a manner that will satisfy the requirements of this document.

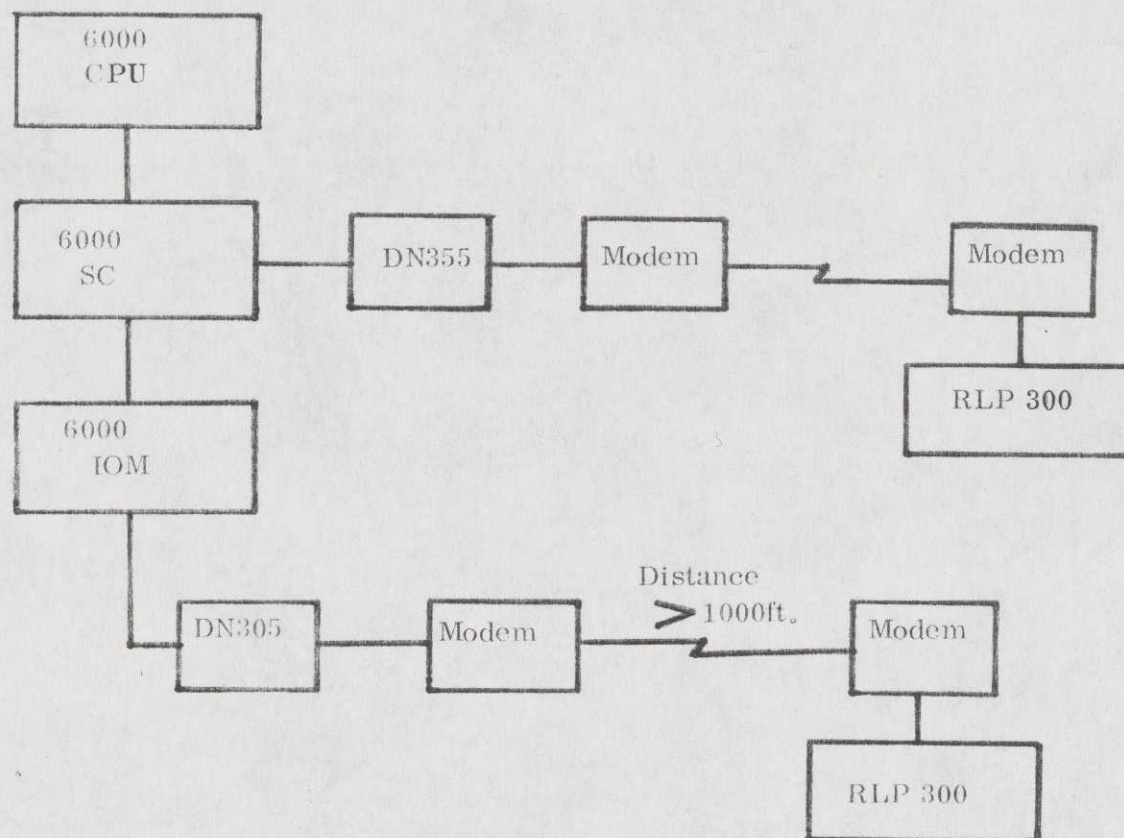
The printer mechanism, control electronics, power supply and cabinet are defined in the MBP 12 specification identified in paragraph 1.5.

1.1 Product Objectives

The objective of the RLP 300 is to satisfy the remote printer requirements for the WWMCCS contract. In so far as possible the subsystem will be implemented as a standard product to operate with the GRTS Computer to Computer software interface, as defined in the respective document referenced in section 1.5. Although the WWMCCS remote printer communication installations will be dedicated, full duplex lines, only four wire Two Way Alternate (TWA) operation will be employed.

1.2 Physical Subsystem Configuration

It is a requirement that the subsystem be housed in a single free standing cabinet.

1.3 System/Subsystem Configuration

The above diagram shows that the RLP 300 will be connected to the DN 355 or DN 305. Modems will be used only when the communication distance is greater than 1000 feet. For communication distance of 1000 feet or less the RLP 300 will be direct connected to the communication processor. Since the DN 305 does not have the capability of generating data clocks, it is a requirement that the RLP 300 provide an optional clock that can be installed or enabled whenever the subsystem is direct connected to the DN 305.

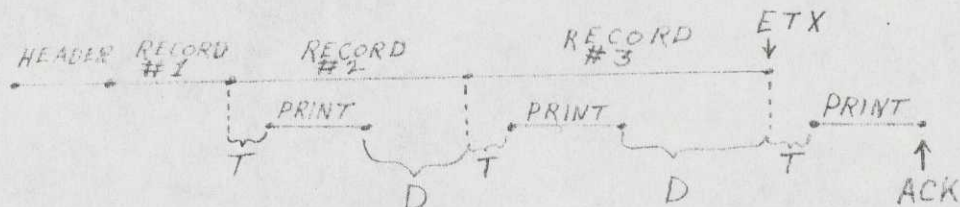
Throughout this document the term "user system" refers to the communication processor (DN 355 or DN 305).

1.4 Subsystem Performance

The WWMCCS application requires that the remote line printer have a minimum print speed of 150 lines per minute. The MBP 12 printer meets this requirement with a print speed of 300 lines per minute when printing 56 contiguous characters. However, it is also required that the subsystem have the capability of operating at 2400 bits per second.

It is to be noted that the effective print rate of the subsystem can be transmission limited. That is, at 2400 bits per second it is possible for the data transmission time to exceed the time required to print the data.

The diagram below illustrates how the transmission rate cannot, in all cases, support a 300 line per minute print rate.



- T = Time to transfer the communication controller buffer to the printer line buffer, approximately 3 ms. maximum.
D = Time difference between record transmission time and print time, is dependent on record size and transmission rate.

From the diagram it can be seen that D must be less than or equal to zero in order to obtain the maximum print rate of 300 lines per minute. At 4800 bits per second this does not pose much of a problem since a 110 character record requires less than 200 milliseconds of transmission time.

At 2400 bits per second it must be recognized that relatively long records (greater than 80 characters) will not drive the printer at the minimum (150 LPM) print rate prescribed by WWMCCS.

Table 1 lists the subsystem effective print rates for various line sizes, and transmission at 2400 bits per second. The effective print rates listed in Table 1 assumes multiple block transfer with record size as listed, and no turn around time between acknowledgement and the beginning of another block.

1.4.1 Computation

The data in Table 1 was computed as follows:

$$RTT = (CPL + 3)3.3$$

$$BTT = (RTT) (LPB) + (13) (3.3)$$

$$EPR = \frac{60 (LPB)}{BTT + 200} \quad \text{where } D > 200$$

$$EPR = \frac{60 (LPB)}{RTT + (200) (LPB)} \quad \text{where } D < 200$$

Where:

RTT = Record Transmission Time

BTT = Block Transmission Time

CPL = Characters Per Line

LPB = Lines Per Block

EPR = Effective Print Rate

There are 13 overhead characters per block, with an additional 3 overhead characters per record (print line).

The character transmission time was rounded off to 3.3 milliseconds per character.

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Characters Per Line	Lines per Block	Total Character	Block Xmission Time sec.	Record Xmission Time ms	D	Effective Print Rate LPM
132	2	283	.9339	445.5	246	105
120	2	259	.855	406	206	113
110	2	239	.789	373	173	121
100	3	322	1.063	340	140	142
80	3	262	.865	274	74	169
60	5	328	1.082	208	8	234
50	6	331	1.092	175	-25	261
40	7	314	1.036	142	-58	272
30	9	310	1.023	109	-91	282*
20	14	335	1.106	76	-124	292*
10	24	325	1.073	43	-157	298*

* Character selection could reduce the print rate to worse case of 272 lines per minute.

Table 1 RLP 300 Effective Print Rate At 2400 Bits Per Second Transmission

1.5 Applicable Documents

MBP-12 Buffered Line Printer --- C002-0
Dated October 12, 1970

Printer Forms Specifications For Honeywell Line Printers --- 280
Dated October 20, 1970

Computer - To - Computer Communication Disciplines, EPS-1
43A177704, Rev. C

GRTS/355 Programming Reference Manual --- CPB - 1664-1

Printer Ribbon Purchase Specification, PO3850014, Rev. 4

2.0 INTERFACE

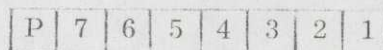
The electrical interface of the subsystem shall be synchronous, bit serial and conform to the requirements of EIA standard RS 232C. The interface shall have the capability of meeting the criteria of the standard low level interface in accordance with MIL STD 188C, paragraph 7.2.1.

The interface selection shall be field changable, and require no more than a single card change to adapt to RS 232C interface to the standard low level MIL STD 188C interface.

The data transfer rate of the subsystem shall be up to 9600 bits per second. When the internal subsystem clock is enabled (direct connected to the DN 305) the data transfer rate shall be selectable, 2400 or 4800 bits per second.

2.1 Character Set

The character set and character code definition for the remote line printer is contained in Table 2. Each character received from the user system will contain odd parity in the most significant bit position, as shown below.



↑ Odd parity, most significant bit position.

The printable characters are defined in row zero column two through row fifteen column five. The lower case characters (row 0, column 6 through row 14, column 7) shall be interpreted by the subsystem as upper case characters in row 0, column 4 through row 14, column 5 respectively.

The occurrence of SYN characters (0010110) and DEL characters (1111111) with odd parity, between SOH and ETX will be included in the BCC calculation but will not be processed as printable characters.

Characters in column 0 and 1 of Table 2 marked with an asterick are illegal if not preceded by a Record Separator character and will be considered format errors.

TABLE 2
Character and Code Set For RLP 300

Bits					COLUMN										
b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	ROW	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	*NUL	*DLE	SP	0	@	P	`	p
0	0	0	0	1	1	1	1	SOH	*DC1	!	1	A	Q	a	q
0	0	1	0	0	0	0	2	STX	*DC2	"	2	B	R	b	r
0	0	1	1	1	1	1	3	ETX	*DC3	#	3	C	S	c	s
0	1	0	0	0	0	0	4	*EOT	*DC4	\$	4	D	T	d	t
0	1	0	1	1	1	1	5	*ENQ	*NAK	%	5	E	U	e	u
0	1	1	0	0	0	0	6	*ACK	SYN	&	6	F	V	f	v
0	1	1	1	1	1	1	7	*BEL	*ETB	'	7	G	W	g	w
1	0	0	0	0	0	0	8	*BS	*CAN	(	8	H	X	h	x
1	0	0	1	1	1	1	9	*HT	*EM	)	9	I	Y	i	y
1	0	1	0	0	0	0	10	*LF	*SUB	*	:	J	Z	j	z
1	0	1	1	1	1	1	11	*VT	*ESC	+	;	K	[	k	{
1	1	0	0	0	0	0	12	*FF	*FS	,	<	L	\	l	
1	1	0	1	1	1	1	13	*CR	*GS	-	=	M	]	m	}
1	1	1	0	0	0	0	14	*SO	RS	.	>	N	^	n	~
1	1	1	1	1	1	1	15	*SI	US	/	?	O	—	o	DEL

*Note:

Characters in column 0 and 1 marked with * are illegal characters

2.1.1 FONT

The print drum presently provided on the MBP 12 printer is a standard 63 character ASCII drum (HISI drawing, 60114499). The font is full size (.100 inches) open gothic. The underline character is .019 inches below the frame centerline and the circumflex is .025 inches below the frame centerline.

A second drum with reduced height (.085 inches) open gothic characters shall be available for applications where a functional underline character is a requirement. The character set on this drum will be the same as the standard 63 character drum. The circumflex character will be located on the frame centerline. The underline character must function as both a free-standing print symbol as well as an underscore for all other symbols which can be printed. That is, it must be capable of overprint without impinging previously or subsequently printed symbols which are placed in the same print position.

2.2 Software Interface

In so far as possible the software interface will conform to the programming discipline as defined in the GRTS/355 Manual referenced in section 1.5. It is necessary that each record (print line) contain a check character, since the subsystem will receive multiple record data blocks and start printing upon receipt of the first record. If check character verification was delayed until the end of the data block, it would be necessary to delay the start of printing until the entire block was received.

2.2.1 Message Format

The printer subsystem shall receive and interpret the following message format from the user system.

SYN SOH FC SC AC OC IC STX TEXT ETX BCC

SYN - Synchronization characters. The synchronization field contains four identical 7-bit bytes with a bit configuration of 0010110.

SOH - Start of Header Character (0000001).

FC - Format Code. The format code specifies the meaning of the message and the format of the text of the message. The RLP300 is required to recognize two format codes:

1001001 - This is the information message FC and will specify no split records, and character compression.

1000010 - This FC will specify a service message and instruction is contained in the OC character. When this FC is used, no text will be present. That is, ETX will immediately follow STX.

SC - Sequence Code. The sequence code is used to assure that data is neither lost or used more than once. This code will alternate between 1000001 and 1000010. A changed SC (different from previous SC) will indicate a new block transmission. An unchanged SC (same as previous SC) will indicate a retransmission of the previous block.

AC - Address Code. Initially the AC will always be set to 1000000. However, it is desirable that the subsystem be capable of operating in the poll and select mode. For poll and select operation the five least significant bits shall contain a binary number (0 through 31) to identify a unique printer.

- CC - If the format code specifies a service message, this character will be set to (1000100) indicating a disconnect to the subsystem. If the format code specifies an information message, this character will be set to (1000000) indicating a block of text to be printed. A disconnect shall be interpreted by the subsystem as an initialize command. All counters and SC registers must be reset. The next SC transmitted by the user system following a disconnect will be 1000001. It is required that the subsystem acknowledge receipt of a disconnect message.
- IC - This character will not be used, but must be set to 1000000.
- STX/ETX - Start of Text/End of Text. These codes are the standard ASCII characters of 0000010 and 0000011 respectively.
- BCC - Block Check Character. The BCC is a modulo 2 sum of all characters, starting with FC through ETX. The BCC calculation is from the 7 data bits of the characters, and does not include the parity bit. Odd parity is added to the BCC as all other characters.

2.2.1.1 Text Format

The text may contain up to 324 characters including data and control characters from STX to ETX. It is possible that a maximum of 108 records may be contained within the text. The text format is shown below:

STX-DATA-SLEW-RS-RCC-DATA-SLEW-RS-RCC----ETX-BCC

Data - The data field will contain one record (up to 132 characters) and may contain compressed characters, see paragraph 2.3.2. The record will always end with a slew code and RS. Should a record begin with a slew code, then no data would be contained in the record.

Slew - The slew code specifies the vertical positioning of the paper, and is required whether paper advance is desired or not. see paragraph 2.3.1.

RS - Record Separator (0011110). The record separator will specify the end of the record and will be interpreted by the subsystem as a print and slew command.

RCC - Record Check Character. The record check character is a 7-bit, plus odd parity and reflects the BCC calculation following each RS. The BCC calculation starts after the SOH character and upon completion of the record the BCC is inserted after the RS character. Calculation of the BCC continues, including the RCC just inserted and continues in this manner through ETX.

2.2.2 Communication from the Subsystem

The printer subsystem is required to send the following messages to the user system.

- (1) Select Service message when the subsystem is placed on-line. This message is sent to the user system whenever the subsystem is powered up and made ready to receive data. It is desirable that this function (subsystem ready) be provided by a separate switch independent of the printer Start switch. With a switch implementation the Select Service message would be transmitted whenever the switch was depressed, changing the subsystem status from not ready to ready.

If a subsystem Ready Switch is not implemented it will be necessary for the subsystem to generate a Select Service message when the subsystem is made ready following a power on. That is, if the subsystem is placed off-line and back on-line without a power off-on sequence, no select message would be sent to the user system.

- (2) Acknowledgement Information message (block received without error).
- (3) Negative acknowledgement information message for the following reasons only.
 - a) BCC or CC error (communication line)
 - b) Character Parity (communication line)
 - c) Unrecognizable format (missing ETX, STX, illegal character, etc.)
 - d) SC error, this negative acknowledgement is sent to the user system whenever the subsystem detects an unexpected sequence code.

- (4) Wait information message when the subsystem is inoperable and requires manual intervention.

The format for the above messages is defined as follows:

```

SYN SOH FC SC AC OC IC STX ETX BCC
          *           *

```

* These characters are not used but are reserved and must be set to 1000000.

SYN- Synchronization characters. Four 7-bit + parity (0010110)

SOH - Start of Header (0000001)

FC - Format Code. When sending an information message the value of the format code shall be (1001000). When sending a service message the value shall be (1000010).

AC - Address Code. For the initial implementation the AC will be set to 1000000. For poll and select operation, when implemented, this character will contain the device identification in the five least significant bits.

OC - Operation Code. The OC contains an instruction field and an acknowledgement field in the following format.

```

BITS      7   6   5   4       3   2   1
Use       1       ACK      INSTRUC-
                FIELD      TION FIELD

```

Bits 1 - 3 of the operation code define the type of instruction to be performed as follows:

<u>3 2 1</u>	<u>INSTRUCTION</u>	<u>MEANING</u>
0 0 0	no request	Acknowledgement contained in ACK field.
1 0 0	wait	Subsystem inoperable manual intervention required.
0 1 0	select	Subsystem on-line in initialized state.

Select - The select message (instruction field 010) is the only unsolicited message sent to the user system. This message is transmitted to the user system whenever the subsystem has been initialized locally, i.e. without the receipt of a disconnect from the user system. Whenever a select message is sent to the user system the FC will be set to 1000010, and the acknowledgement field of the OC will be zero. The user system will not acknowledge a select message from the subsystem.

Wait - The wait message (instruction field 100) is a special type of negative acknowledgement that must be sent to the user system whenever an unrecoverable error is detected in the printer. This message will be interpreted by the user system as an indication that the block was received without error, but manual intervention is required before printing can commence or continue. The FC will be set to 1001000 when a wait message is sent to the user system.

Acknowledgement - bits 4 - 6 of the operation code define the type of acknowledgement as follows:

<u>6</u> <u>5</u> <u>4</u>	<u>Meaning</u>
0 0 0	Positive acknowledgement. No errors detected while receiving message from user system.
0 0 1	Negative acknowledgement. Error detected while receiving message from the user system for the following reasons only: a) RCC or BCC error b) Character parity c) Unrecognizable format
1 0 0	SC error. This negative acknowledgement will be sent to the user system whenever the subsystem detects an unexpected sequence code.

2.3 Control Characters

The control codes, within the text, will be a record separator (0011110) and a unit separator (0011111). These control characters will specify line or page slewing and character compression respectively and will be imbedded in the text of the block.

2.3.1 Paper Slewing

Each line of data (record) in the text will end with a record separator character (0011110) preceded by a seven bit slew code. The slew codes are defined as follows:

Code	Meaning
7 6 5 4 3 2 1	
0 1 1 0 0 0 0	No slew
0 1 0 0 0 0 0	Slew to top of page
0 1 1 0 0 0 1	Slew one line
0 1 1 0 0 1 0	2
0 1 1 0 0 1 1	3
0 1 1 0 1 0 0	4
0 1 1 0 1 0 1	5
0 1 1 0 1 1 0	6
0 1 1 0 1 1 1	7
0 1 1 1 0 0 0	8
0 1 1 1 0 0 1	9
0 1 1 1 0 1 0	10
0 1 1 1 0 1 1	11
0 1 1 1 1 0 0	12
0 1 1 1 1 0 1	13
0 1 1 1 1 1 0	14
0 1 1 1 1 1 1	15
1 0 0 0 0 0 1	VFU-1
1 0 0 0 0 1 0	VFU-2

2.3.2 Character Compression

When a record contains a series of three or more of the same data characters, the character will be transmitted once followed by a unit separator character (0011111). The unit separator will be followed by a seven bit character (1xxxxxx) where xxxxxx is a binary number from 2 to 63 specifying the number of times the character is to be repeated.

3.0 OPERATIONAL REQUIREMENTS

In general, the operational requirements of the subsystem are to receive data in the format defined in paragraph 2.2.1 and provide the necessary integrity that will permit an acknowledgement to the user system that the data has been printed. A flow chart depicting the operation of the subsystem is contained in Figure 3.0.

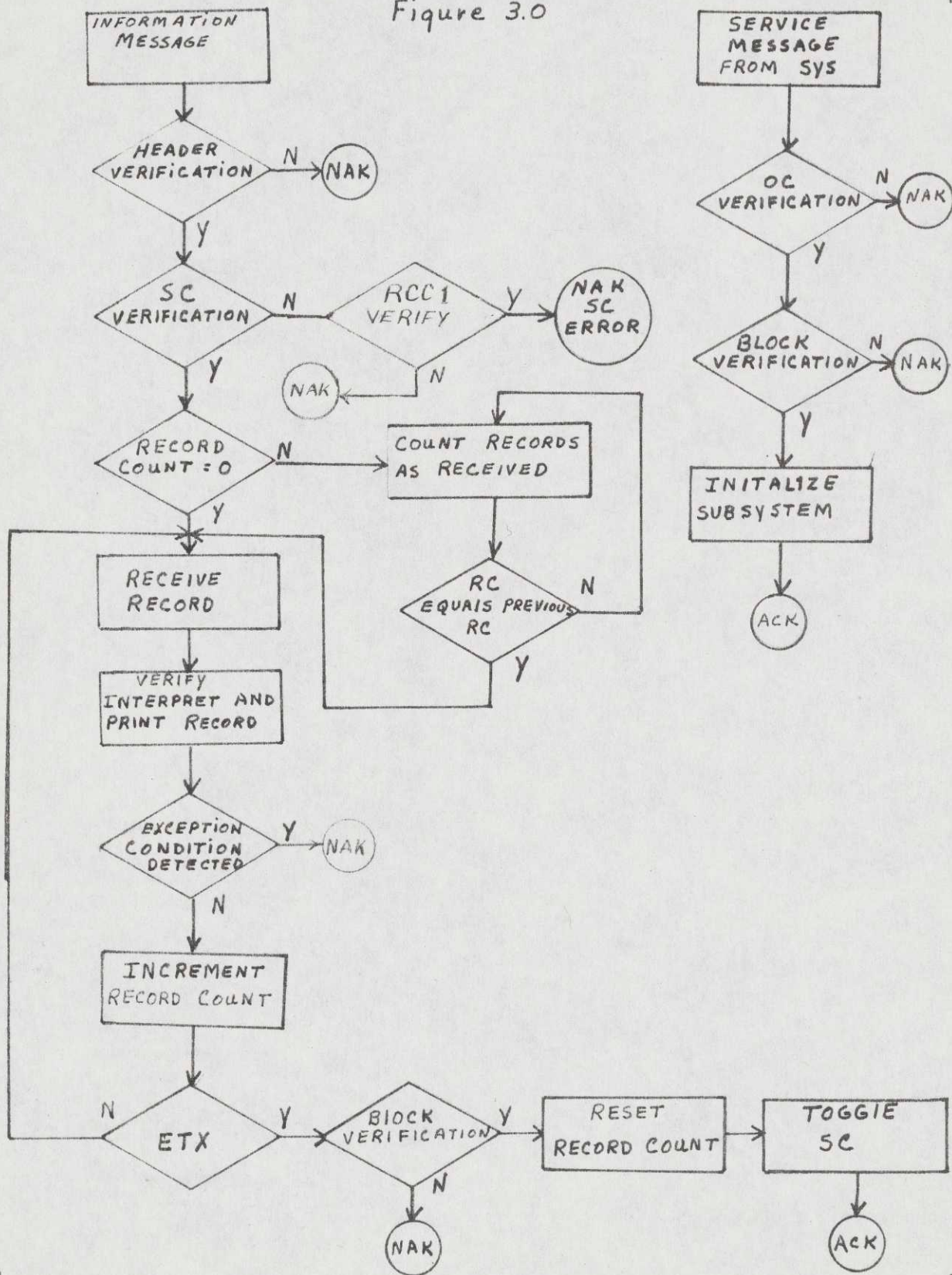
The dialog between the user system and subsystem is limited and restricts the reporting of exception conditions as either recoverable errors or conditions requiring manual intervention.

It is to be noted that the user system considers a block to be the smallest recoverable data segment. The subsystem, while receiving data, will check character parity, verify and print records, but will delay acknowledgement until a complete block has been received and printed. This difference in data handling requires that the subsystem augment the system in data recovery.

3.1 Communication Procedures

Both the DN 355 and DN 305 transmit mark hold (all ones) between blocks. The subsystem ignores the mark hold as well as any characters that might appear between blocks. The subsystem is alerted by the occurrence of a SYN character. Once a SYN character is received, the subsystem begins verifying characters and format. The beginning of a block will be recognized by the subsystem when an SOH character immediately follows two or more adjacent SYN characters. Once the beginning of a block is recognized, the detection of any error will result in the subsystem halting the printing operation and reporting a negative acknowledgement upon receipt of the ETX. Should the subsystem fail to recognize the ETX character, data reception would continue and the mark hold would be recognized as Delete Characters with incorrect parity. Upon detection of two delete characters with even parity the subsystem would halt data reception and send a negative acknowledgement to the user system.

Figure 3.0



It is necessary that once a transmission has started from the user system, one complete block must be transmitted before an acknowledgement can be received from the subsystem. Upon transmission of a block the user system will delay any further transmission to the subsystem until an acknowledgement is received or n seconds have elapsed. If n seconds elapse without an acknowledgement, the system will repeat the transmission. If after k attempts an acknowledgement is not received, the user system will report a subsystem failure to the system operator.

In order to prevent duplicate printing when an error is detected after printing is started, the subsystem is required to maintain a count of the number of records successfully printed within a data block. see section 3.2 item 2. If a block is printed without the detection of an exception condition a positive acknowledgement is transmitted to the user system and the record count reset.

3.1.1 Message Sequence

The sequence code (SC) character within the block header is used to identify a continuing block sequence or a block retransmission. Normally, the SC will alternate between octal 101 and 102. Failure of the SC to alternate will be interpreted by the subsystem that the block is a retransmission of the previous block. Whenever the subsystem responds to a message with a positive acknowledgement (ACK) the following block must contain the alternate SC. The SC scheme is depicted in Figure 3.1.

Following initialization of the subsystem the message sequence is cleared and an SC of octal 101 or 102 will be accepted. From this point the subsystem is required to remember the last acceptable SC (the last SC where the block was acknowledged), and verify all following sequence codes. If a message with an SC of octal 101 is received, printed and acknowledged, the following SC must be octal 102.

An SC error will be reported only when an unexpected SC is received, no format errors or detected in the header and the first Record Check Character (RCC 1) verifies.

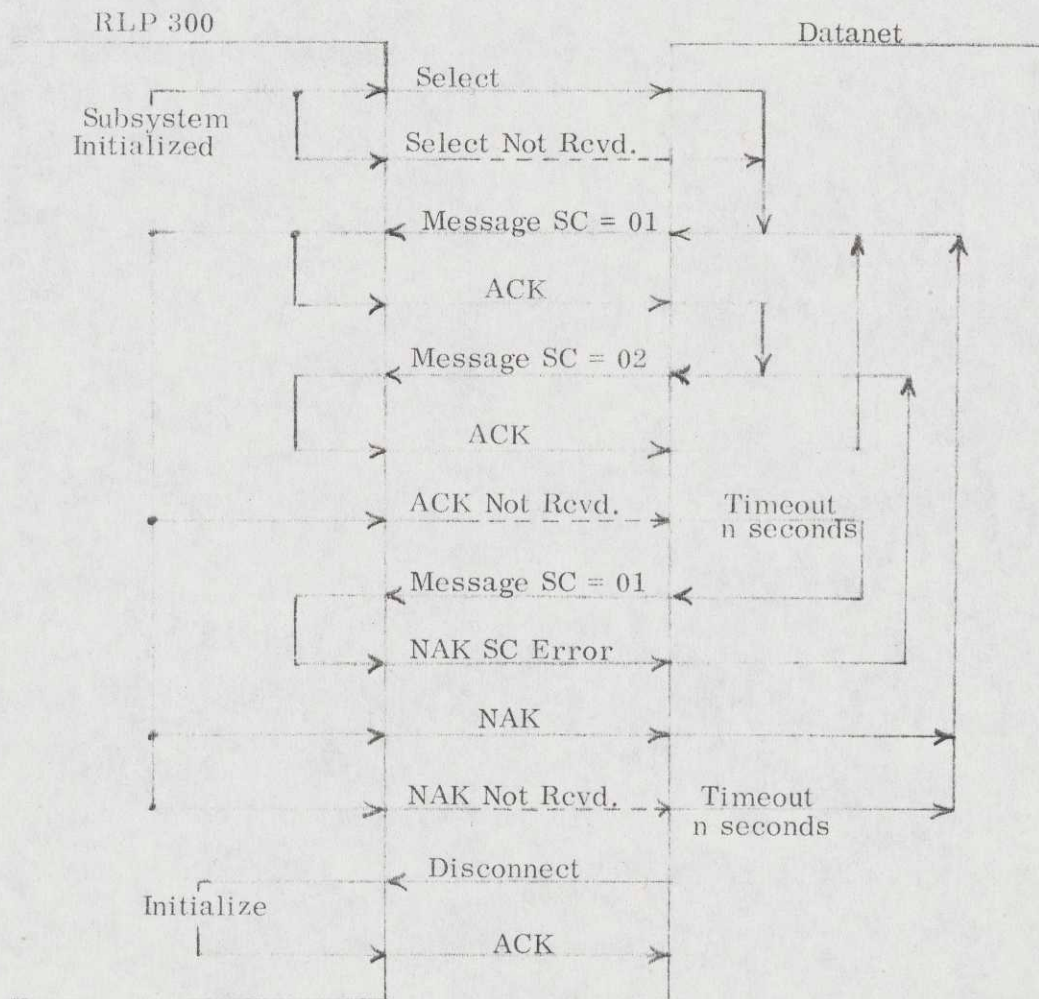
Example:

The subsystem accepts, prints and acknowledges a block with an SC of octal 101. The user system fails to receive the ACK and repeats the transmission with the same SC (octal 101). The subsystem is expecting an SC of octal 102 and considers the 101 out of sequence. Data reception continues, and if RCC 1 verifies, the record will not be printed and an SC error will be reported after receipt of the block. If RCC 1 does NOT

3.1.1 Message Sequence (cont.)

verify a NAK will be reported following receipt of the block. In either case (termination of NAK or SC error) the subsystem will still expect an SC of octal 102. The subsystem expected SC will be altered only when a positive acknowledgement is sent to the user system. An exception is subsystem initialization in which case the expected SC will be neutralized and the subsystem will accept an SC of octal 101 or 102.

Figure 3.1 Message Sequence



3.2 Recovery

It is a requirement that errors requiring operator intervention, such as form depletion or paper jams, will not cause the system to halt. The system operator shall be notified of such an event, and printing resumed from the point of interruption upon correction of the condition. In the event recovery procedures are required, no record shall be reprinted unless the recovery requires back spacing to the head of form. This requirement is necessary in the event preformatted forms are being used.

In general, recovery is a system responsibility. However, since the user system is block oriented and the subsystem must perform on a record basis, it is necessary that the subsystem augment the system recovery procedures.

The subsystem is required to attempt recovery of soft errors that occur within the printer electronics, such as, parity errors in the pattern generator and line buffer. The failure of the subsystem to recover from a soft error would result in the error being reported to the user system as a hard error, manual intervention required.

Exception conditions involving the user system and the recovery procedures are as follows:

- 1) Failure of the subsystem to receive data from the user system. The user system would make n attempts to get a positive acknowledgment from the subsystem. If after n attempts, no response was received or a negative response was received, the user system would report a subsystem failure to the system operator.
- 2) Character parity or record check character error. As specified in paragraph 3.1, the subsystem is required to store the Sequence Code and maintain a count of the records successfully printed. Should an exception condition be detected, all following data will be ignored by the subsystem and a negative acknowledgment sent to the user system upon receipt of the ETX. The next transmission from the user system will contain the same sequence code as the previous block. The subsystem will ignore all records that were previously printed and start printing with the record that was to have been printed when the error was detected in the previous block. Example - The subsystem detects a recoverable error in record number n. The subsystem stops printing and ignores all following data. When the ETX character is received a negative acknowledgment is sent to the user system. The user system retransmits the block without toggling the SC. The subsystem recognizes the SC as a retransmission of the previous block and starts counting records. When record number n is received the subsystem starts printing and completes the block.

3.2 Recovery (continued)

3) Failure to Print

This condition would be reported as Manual Intervention Required in the instruction field of the operation code. The user system will report this condition to the system operator. No automatic recovery will be attempted. It is required that the user system transmit a disconnect to the subsystem so that the SC can be reset. The subsystem must acknowledge receipt of the disconnect.

4) Failure of the User System to receive an acknowledgment.

If the user system fails to receive or recognize the acknowledgment from the subsystem, the block will be retransmitted.

The SC would be the same as the previous block and if the subsystem has transmitted a positive acknowledgement the SC would be recognized as out of sequence and a negative acknowledgement, SC error would be reported to the user system.

4.0 RELIABILITY

This section is intentionally omitted from the initial release of this document, but will be included with revision B.

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